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Flying Hour Cost Estimating At Commander Naval Air Forces Pacific (COMNAVAIRPAC)

By LCDR Paul J. Bourgeois

OVERVIEW

This research examined the Tactical Air (TACAIR) portion of the Commander Naval Air Forces Pacific (COMNAVAIRPAC) historical flight hour data to determine the correlation between dollars budgeted for the FHP and the hours actually flown. An analysis of the actual FHP execution of the budget for Fiscal Years (FYs) 1999, 2000, and 2001 was undertaken for four Continental United States (CONUS) based Carrier Air Wings (CVWs).

The COMNAVAIRPAC Comptroller and Flight Hour Program Manager have used FHs as a predictor of Fuel, Aviation Depot Level Repairables (AVDLRs), and Other Maintenance costs. They have sought a more effective cost prediction model for the air wings they fund. The intention has been to find a cost estimation method that could be applied to the Inter-Deployment Training Cycle (IDTC) and Fuel, AVDLRs and Other Maintenance costs to better analyze and report projected versus actual flight hour performance.

If such a model was to exist, COMNAVAIRPAC would have a more powerful tool for:

- accounting and budget analysis,
- budget projection and execution,
- improving the formulation of the Program Objectives Memorandum (POM) and budget, and
- executing the budget and other resource reporting (including reconciliation to the OP-20 report from the Pentagon).

Such a model could also be used throughout the Pacific Fleet and elsewhere in the Navy.

INTRODUCTION

The FY 2002 Navy FHP is part of the $5.232 billion Air Operations portion of the Operations and Maintenance, Navy (O&M,N) annual appropriation account. Of that portion, COMNAVAIRPAC is responsible for over $1.856 billion. The FHP is broken down into Fuel, Aviation Depot Level Repairables (AVDLRs), and Other Maintenance costs. The Navy and Marine Corps team uses the FHP to support the day-to-day flight operations and maintenance associated with Naval aviation.

As a brief overview of the FHP process, the Assistant Chief of Naval Operations (CNO) for Air Warfare (N-78) is responsible for formulating the annual funding required for each aircraft type/model/series (T/M/S). The primary budget tool utilized is the Operational Plan (OP-20).

Throughout the year, the N-78 staff works closely with their counterparts at the major claimant level, in this study (Commander in Chief, Pacific Fleet (CINCPACFLT)) and the Air Type Commander (TYCOM) level COMNAVAIRPAC to monitor FHs flown. COMNAVAIRPAC hands out quarterly grants to each squadron under his command based on the upcoming requirements.

On a monthly basis, Fiscal Year To Date (FYTD) feedback from the squadrons executing the FHP are collected, analyzed, and fed back up the chain of command to assess how costs for Fuel, AVDLRs, and Other Maintenance are tracking relative to the OP-20. At the end of the FY, COMNAVAIRPAC certifies the obligations and these figures are used to cost out the year's requirements. Additionally, other variables, such as an inflation factor, an aircraft-aging factor, and other program change factors are added into the cost calculation. These data points are also used to justify future annual funding requirements.

TEST FOR A PREDICTIVE MODEL

To provide answers to the question, "Are FHs a good predictor of total costs incurred by COMNAVAIRPAC?", regression and analysis of variance of the cost prediction model were used. In this section, all mean values and values in the regression are in dollars per hour. The results of this regression and analysis of variance are intended to enable the FHP staff to gain a macro perspective of the costs associated with the FHP and the efficacy of FHs as a predictor of costs.

Figures 1.1 and 1.2 show the regression analysis for each of the costs analyzed: Fuel, AVDLRs, Other Maintenance, and Total costs for all four CVWs, over a three-year period.

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Master Data Regression

SUMMARY OUTPUT		Mean	$0.701105
Master Data	**Fuel as Y**	**Std Dev**	**$1.041178**
Regression Statistics		**CV**	**1.485052199**
Multiple R	0.801460913		
R Square	0.642339595		
Adjusted R Square	0.642038027		
Standard Error	96.71155612		
Observations	1188		

ANOVA

	df	SS	MS	F	Significance F
Regression	1	19922106.69	19922106.69	2129.994682	4.666E-267
Residual	1186	11092806.35	9353.125087		
Total	1187	31014913.05			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	-28.93840894	4.846568603	-5.9709067	3.1134E-09	-38.44721427
X Variable 1	0.834463658	0.018080822	46.15186542	4.666E-267	0.798989691

SUMMARY OUTPUT		Mean	$ 2.312540
Master Data	**AVDLR as Y**	**Std Dev**	**$3.363206**
Regression Statistics		**CV**	**1.454334224**
Multiple R	0.550570703		
R Square	0.303128099		
Adjusted R Square	0.302540517		
Standard Error	436.0576365		
Observations	1188		

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	98094740.81	98094740.81	515.8909758	4.1007E-95
Residual	1186	225513467.1	190146.2623		
Total	1187	323608207.9			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	100.7185137	21.85243765	4.609028767	4.48323E-06	57.84476274
X Variable 1	1.851666027	0.081523665	22.71323349	4.1007E-95	1.691719327

Figure 1.1—Regression analysis for fuel and AVDRL costs.

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Master Data Regression

SUMMARY OUTPUT		**Mean**	**$0.951899**		
Master Data	**Maint as Y**	**Std Dev**	**$2.085140**		
Regression Statistics		**CV**	**2.190506739**		
Multiple R	0.37115389				
R Square	0.13775521				
Adjusted R Square	0.137028191				
Standard Error	300.9902077				
Observations	1188				

ANOVA

	df	SS	MS	F	Significance F
Regression	1	17165911.8	17165911.8	189.4794622	4.18723E-40
Residual	1186	107445794.7	90595.10512		
Total	1187	124611706.5			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	39.26739441	15.08371645	2.603297041	0.009348437	9.673647756
X Variable 1	0.774592406	0.056271976	13.76515391	4.18723E-40	0.664188674

SUMMARY OUTPUT		**Mean**	**$0.701105**	**$2.312540**	**$0.951899**
Master Data	**Total as Y**	**Std Dev**	**$1.041178**	**$3.363206**	**$2.085140**
Regression Statistics		**CV**	**1.485052199**	**1.454334224**	**2.190506739**
Multiple R	0.680442327				
R Square	0.463001761				
Adjusted R Square	0.46254898				
Standard Error	578.868202				
Observations	1188				

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	342652462.6	342652462.6	1022.573349	2.5439E-162
Residual	1186	397414836.7	335088.3952		
Total	1187	740067299.4			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	111.0474992	29.00919565	3.828010282	0.000135929	54.13242864
X Variable 1	3.460722092	0.108222981	31.97770081	2.5439E-162	3.248392227

Figure 1.2—Regression analysis for other maintenance and total costs.

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Fuel

For the entire data set, fuel costs have both an F-statistic and a T-statistic significance approaching zero. This implies that the regression equation is significant to over 99% and is preferred to the simple mean of the data. However, the Coefficient of Determination (R^2) has a value of .642. This means that FHs explain only 64.2 percent of the variation of fuel costs across all T/M/S of aircraft.

The Coefficient of Variation (CV) shows a similar pattern. While the mean cost for fuel for all aircraft, for all years, is approximately $701.11 per FH, the standard deviation is approximately $1,041.18. These two numbers combine to give us a CV of 1.4850 or 148.50 percent.

In other words, by using the mean equation, you can expect to be off as much as 148.50 percent on your estimation. The regression slope, and therefore the cost, of $834.46 per FH only explain 64.2 percent of the costs.

AVDLRs

AVDLRs show a similar pattern. The F- and T-statistic significance show values that approach zero, but the R^2 value is only .303; thus 30.3 percent of the variation of AVDLR costs are explained by FHs across all T/M/S.

The mean for all the data is approximately $2,312.54 per FH with a variation of $3,363.21. This gives a CV of 1.4543 or 145.43 percent error when using the mean as the predictor.

The regression slope is $1,851.66 per FH across all T/M/S. Explained variation accounts for only 30.3 percent of AVDLR costs.

Other Maintenance

Maintenance versus FH regression, like the two previous factors, shows F- and T-statistic significance approaching zero, but with an R^2 value of only 13.7 percent.

The mean for Other Maintenance is $951.90 per FH with a variation of $2,085.14. These combine to give a very high CV of 2.1905 or 219.05 percent.

The regression slope is $774.59 per FH across all T/M/S. Explained variation accounts for only 13.7 percent of Other Maintenance costs.

Total Costs

For total costs, which are simply the addition of all the previous costs per month, the analysis also shows similar patterns. F- and T-statistic significances approach zero with only 46.3 percent of the variation of costs defined as measured by the R^2.

The arithmetic mean of the data is $3,965.54 per FH with a variation of $5,083.51. The CV 1.2819 or 128.19 percent is the error expected when using the mean.

The regression equation, with a slope of $3,460.72 per FH, therefore may be expected to predict 46.3 percent of the total costs incurred per month.

Discussion

The bottom line for the test as a whole is that FHs can be expected to predict, on average, just under half of the total costs incurred by COMNAVAIRPAC. This is a bit misleading, however, because the model as a whole takes into account different T/M/S

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of aircraft, each of which burn fuel at a different rate, and each of which have different AVDLR and maintenance costs associated with them. Additionally, within each of the T/M/S of aircraft, aircraft age plays an important factor in the cost and amount of AVDLRs and Other Maintenance. To take this model as a whole is analogous to comparing eight different types of automobiles, differing in age, condition, driving style, and trying to treat them as equivalents.

While the FHP has seen a decline in the number of hours flown in the past decade, costs, especially AVDLR costs, have actually risen. Additionally, the average age of the aircraft in the Naval inventory is expected to be nearly 20 years old by 2005 (Jondrow, 2002). This has lead to a conscious decision on the part of lawmakers and budget analysts to balance the higher costs associated with an aging fleet with the high costs associated with the development and procurement of new aircraft.

COST SUMMARIES

Cost summaries included an analysis of fuel, AVDLRs, other maintenance costs, and total cost.

Fuel

The analysis has shown that fuel is the most correlated factor with FH. Regardless of the mission or the T/M/S of aircraft, the more hours flown, the more COMNAVAIRPAC expects to spend on fuel.

While this conclusion is logical, what was not expected was the range of correlation between squadrons flying the same T/M/S. While most T/M/S of aircraft averaged an R^2 value of over 66 percent, there were some squadrons with R^2 values of .2763 and .0237. This shows that using FH as a sole predictor of fuel costs may not always be the optimal solution.

Insight into the wide deviation of fuel costs, or any of the costs for that matter, would provide COMNAVAIRPAC with valuable budget information, as well as, pointed questions to ask about current methods of predicting future costs.

For example, while the average R^2 value for all the T/M/S of aircraft is 66 percent, further examination shows that there is quite a difference between fixed wing and rotary aircraft fuel correlation. Since the helicopter squadrons fly a completely different mission than the fixed wing aircraft (constant flight with a relatively benign take-off and landing vice constant cycling of engines during flight coupled with the beating taken during take-offs and landings), it makes sense that their correlation should be higher. Also, since helicopters do not routinely dump fuel upon a carrier landing as fixed wing aircraft do, and since there is little difference between shipboard and shore-based take-offs and landings for helicopters, one would expect FH to be a better predictor of costs for helicopters. What may prove a better predictor of fuel costs is to break down each of the T/M/S of aircraft and find their individual correlation and cost per FH. This would give COMNAVAIRPAC a more accurate prediction of fuel costs per T/M/S.

AVDLRs

Because of AVDLRs wide variability in costs, high dollar value, and the possibility for credits from previous submissions giving negative monthly values, using FH as a predictor is much more reckless. As shown by the analysis, there are, at times, no correlation whatsoever in the amount of hours flown and the cost of AVDLRs.

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With R^2 values averaging approximately 20 percent across all T/M/S of aircraft, the range of correlations among the squadrons was not as wide as it was for the fuel costs. The highest correlation was an R^2 value of 55.6 percent and the lowest correlation was an R^2 value of just over 1 1/2 percent.

What was as high, or higher, was the deviation in costs per FH. While accurate AVDLR costs can be predicted, if information is broken down and tracked by plane or by block, the reporting of this type of data every month to COMNAVAIRPAC would soon overwhelm anyone who undertook the job of analyzing it.

Additionally, there is little evidence that FH are the best predictor of AVDLR costs. For example, given the scenario of two similar T/M/S of aircraft flying the same amount of hours in a given month, but with one aircraft having 100 FHs on its engine and the other having 2,500 FHs on its engine, the aircraft with the higher FHs would be expected to have considerably higher AVDLR costs. This is not captured in the current Flying Hour Cost Report (FHCR), and thus partially explains the low correlation between FH and AVDLR costs.

Two examples not inherently obvious in this analysis are the overall rise in AVDLR costs from year to year and the effect aging has on aircraft. Specifically, AVDLR cost per flight hour grew sharply in the 1990s. Costs rose 43 percent between FY 1992 and FY 1996 and another 65.5 percent between FY 1996 and FY 2000. (Jondrow, 2002)

For an in-depth analysis of the underlying cause for growth in AVDLR cost per flight and a discussion on the aging effects of aircraft on AVDLR costs per FH for the period FY 1992 to FY 2000, refer to the Center for Naval Analyses (CNA) study dated January 2002. (Jondrow, 2002)

Other Maintenance

Across all T/M/S of aircraft, the highest correlation was an R^2 value of 69.5 percent and the lowest correlation was an R^2 value .03 percent.

While Other Maintenance entails everything up to depot-level repairs to the aircraft, the vast majority of work is routine preventative maintenance system (PMS). It includes everything from checking and replacing lubricants to fixing worn or broken equipment throughout the aircraft.

The wide variability in Other Maintenance costs means that FH are also a poor predictor of costs. Since the same maintenance is not performed per FH for any two aircraft, and since maintenance is often deferred from one month to another or from one IDTC status or FY to another, there is often little correlation between the hours flown and the Other Maintenance performed. Taking the AVLDR example from above, the same two aircraft, flying the same amount of hours could have vastly different maintenance requirements, each with a wide variety of Other Maintenance costs. None of these would be accurately reflected in the FHCR or predicted by the hours flown.

Total Costs

Since total costs are merely the aggregate of the Fuel, AVDLR, and Other Maintenance costs, it follows that weakness in any of the correlations would also cause weakness in the total cost model. Often the strength of the correlation between the FH and fuel costs was overshadowed by the weakness in correlation in FH and AVDLR and/or Other Maintenance.

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As the previous summaries have shown, FHs as a predictor of costs are not the best answer. If the use of FH as a predictor continues, or at least continues as the primary variable to capture costs, decision makers are being underserved. The problem, however, is in the fact that the sheer volume of data required to make FH a valuable predictor of costs would overshadow any benefits derived.

Figures 1.1 and 1.2 describe the outcomes of the regression run on the data. The original data was sliced into different categories using the sort function in Microsoft® Excel and the cost categories (Fuel, AVDLR, and Other Maintenance) for each element were regressed against the FHs associated with them. When the regression equation and Coefficient of Determination (R^2) value showed that the regression equation was the preferred equation (determined to be an R^2 value of over 50 percent) it was used. When the regression equation and Coefficient of Determination (R^2) value showed little or no correlation between the FHs and the costs (determined to be an R^2 value below 50 percent), the simple mean of the data was used as the better cost predictor. For those interested in a more detailed explanation of the methodology used, please refer to the Jondrow study.

REFERENCE

Jondrow, James M. et al *CNA Research on the Cost Growth of Depot-Level Repairables.* CRM D0004644.A2. Center for Naval Analyses (CNA), Alexandria, Virginia, January 2002.

The previous theses abstracts and theses were written by June 2002 graduates of the Naval Postgraduate School.

Congratulations to all graduates from the Naval community!